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Redesigning cheese powder for omission of emulsifying salts

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Objective

To study how the rheology, stability and microstructure of hot cheese emulsions for cheese powder are changed when emulsifying salt is omitted as well as how these properties can be influenced by other means in cheese emulsions without emulsifying salt

Introduction

Cheese powder is a food ingredient widely used as flavour enhancer and functional ingredient in products like snacks, soups and sauces . The present focus on decreasing the use of food additives as well as the general public intake of sodium and phosphate has created a need for development of cheese powders produced without addition of emulsifying salts (ES). As in the production of processed cheese, the emulsifying salts aid in formation of a stable homogenous product by, among other factors, binding calcium, increasing pH or buffer capacity and solubilisation and rehydration of the casein.
The resulting emulsion, called the cheese feed, is subsequently spray dried into the final cheese powder, and therefore requires properties suitable for spray drying.

When the emulsifying salt is removed from the recipes, the stability of the cheese feed decreases and the rheological properties and microstructure (visualised by confocal laser scanning microscopy (CLSM)) are changed substantially (Figure 1).

A number of strategies for improving the properties have been investigated, including:

- Addition of other dairy based ingredients (e.g. buttermilk powder and sodium caseinate)
- Variation of cheese age
- Variation of processing parameters (e.g. mixing time and mixing speed)
- Adjustment of pH with KOH

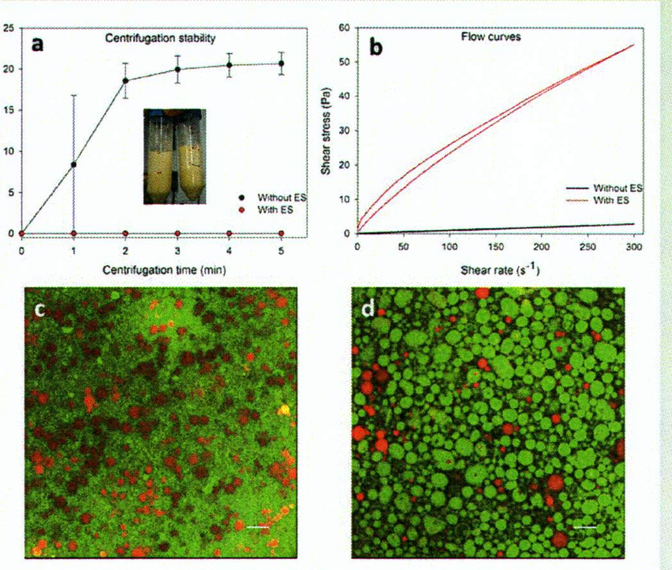

Figure 1: Differences in properties of cheese feeds produced with and without emulsifying salt (ES). Cheese feeds are produced from cheddar, soft white cheese, water and with/without ES. a) Centrifugation stability quantified by measuring the height of the watery middle phase after each of 5 consecutive centrifugations of 1 minute. b) Flow curves measured at 60°C. c) and d) CLSM images of cheese feeds with and without ES, respectively. Green indicates protein, red indicates fat, scale bar 20 µm.

Materials and Methods

Cheese feed was prepared in a Stephan Cooker (Stephan UMC5 electronic, Stephan u. Söhne GmbH) by mixing cheddar cheese (300 g), soft white cheese (200 g), and water (140/160 g, without/with emulsifying salt, ES). Disodium hydrogen phosphate was used as ES in a concentration of 15 g/kg cheese feed. Sodium caseinate and buttermilk powder were used in concentrations of 2.5% and 5%, respectively, on a dry matter basis. The age of the cheddar cheeses ranged from 1 month to 18 months. The ingredients were mixed in the Stephan cooker at 1500 rpm for 5 minutes and heated by applying direct steam for 45 seconds under continuous mixing. All types of cheese feed were prepared at least in duplicate.
Stability of the cheese feeds was analysed by centrifugation for 5 × 1 minute at 1500 rpm at 40°C (SL 16R, Thermo Scientific, Karlsruhe, Germany).
Rheological properties of the cheese feeds at 60°C were analysed using a Haake RS 600 rheometer (Thermo Scientific, Karlsruhe, Germany) or an AR-G2 (TA Instruments, New Castle, DE). Each measurement consisted of a flow curve (taken approx. 15 min after production) using shear rates (up and down sweep) ranging from 1 s^{-1} to 300 s^{-1}.
The **microstructure** of the cheese feeds was visualised using confocal laser scanning microscopy (CLSM) (Inverted Point Scanning Confocal SP5 II, Leica Microsystems, Germany) after staining the fat with Nile red and the protein with FITC.

Results and Discussion

Addition of other dairy based ingredients to cheese feeds without emulsifying salt might be an alternative to emulsifying salt because these ingredients are more acceptable in the final product. Analyses of cheese feed containing either 2.5% sodium caseinate or 5% buttermilk powder (BMP) showed slight improvements in stability and changes in the rheological properties as well as microstructure (Figure 2).

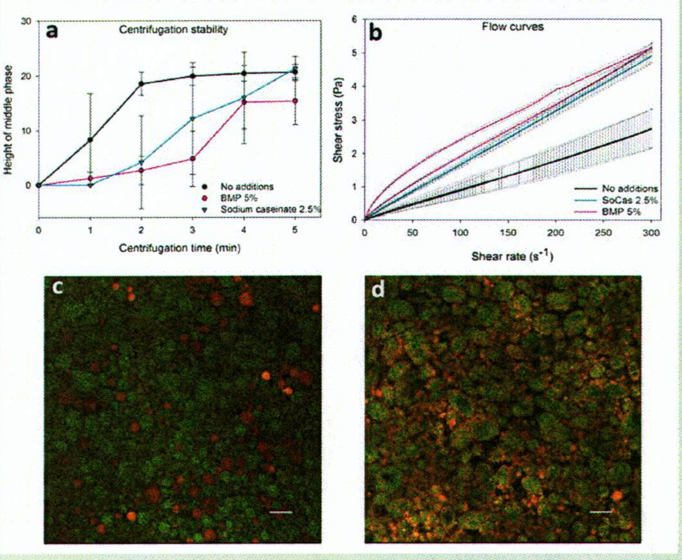

Figure 2: Properties of cheese feeds produced with sodium caseinate or buttermilk powder as alternative to ES. Cheese feeds are produced from cheddar, soft white cheese, water and sodium caseinate/buttermilk powder/no additions. a) Centrifugation stability quantified by measuring the height of the watery middle phase after each of 5 consecutive centrifugations of 1 minute. b) Flow curves measured at 60°C. c) and d) CLSM images of cheese feeds with buttermilk powder and sodium caseinate, respectively. Green indicates protein, red indicates fat, scale bar 20 µm.

The main true emulsifier in cheese feed is the casein of the cheeses and its breakdown products, and the emulsification capacity depends on the intactness of the proteins and hence on cheese maturation degree. The effect of using cheddar cheeses of different ages, ranging between 1 and 18 months was investigated, and differences in cheese properties were observed indicating that cheese maturation degree might be useful as design parameter for cheese feeds without emulsifying salt (Figure 3).

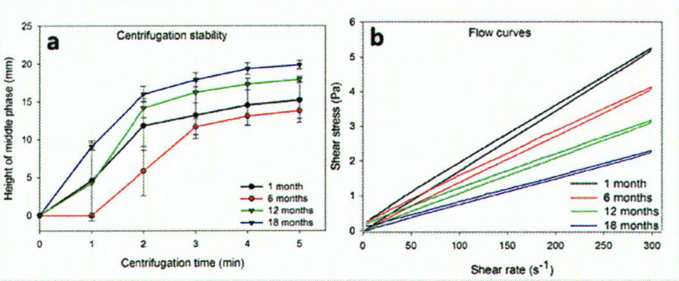

Figure 3:Centrifugation stability and flow curves for cheese feeds prepared from cheddar cheeses of different ages in combination with soft white cheese, water and KOH for final pH ≈ 5.7. a) Centrifugation stability quantified by measuring the height of the watery middle phase after each of 5 consecutive centrifugations of 1 minute. b) Flow curves measured at 60°C.

Replacing the pH buffering effect of ES by adjusting the cheese feed pH with KOH has likewise shown potential to improve the stability of cheese feeds without ES (data not shown). Changing of processing parameters such as mixing time and speed (i.e. severity of mechanical treatment) has indicated that these do influence the properties of cheese feeds without ES, however, no conclusive results have been obtained yet (data not shown).

Conclusions

The omission of emulsifying salts from cheese feed for cheese powder production significantly changes the stability, rheological properties and microstructure of the feeds. A number of strategies have shown potential for improving the properties of cheese feed without emulsifying salts. Only limited improvements were observed by use of each strategy, however, suggesting that several changes have to be made in formulation and processing of cheese feed for cheese powder without emulsifying salt.

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lactosan

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Cheese powder is a food ingredient widely used as flavor and functional ingredient in products like snacks, soups, sauces etc. The present focus on decreasing the use of food additives as well as the general public intake of sodium and phosphate has created a need for development of cheese powders produced without addition of emulsifying salts. As in the production of processed cheese, the emulsifying salts aid in formation of a stable homogenous product, the cheese feed, which is subsequently spray dried into the final cheese powder. The rheological properties, centrifugation stability and microstructure, visualized by confocal laser scanning microscopy, of cheese feeds produced both with and without emulsifying salts have been investigated. When the emulsifying salt was removed from the cheese feed recipes substantial changes in rheology and microstructure were observed along with a marked decrease in centrifugation stability. Cheeses feeds containing emulsifying salt exhibited shear-thinning behavior and at the microstructural level a continuous protein network where the fat globules were entrapped. On the other hand, cheese feeds without emulsifying salt showed almost Newtonian behavior and had shear stresses an order of magnitude lower than the feeds with emulsifying salt at the same shear rates. Microstructural analysis revealed discrete, non-interacting particles of protein and fat. Several strategies for counteracting the destabilization of cheese feeds without emulsifying salts were studied. These included addition of other dairy based ingredients like butter milk powder and sodium caseinate, effects of using cheeses of differing ages, changes in processing parameters such as time and speed of mixing and adjustment of pH using KOH to simulate the increase in pH normally obtained by addition of emulsifying salt. Some of the studied strategies led to improvements in cheese feed stability and changes in rheology and microstructure in a direction towards the observed properties of cheese feeds with added emulsifying salt. However, only small improvements have been seen for individual changes thus the key to success may lie in combination of several of the suggested strategies and further changes in composition and processing of cheese feeds will have to be implemented in order to make complete removal of emulsifying salts from the recipes possible.